Edge Sharpener

Technical Field

[0001] A metal surface contoured for edge sharpening is treated in an electrolytic bath by a method particularly effective for making a ceramic sharpening and/or honing surface on the edge sharpening contour.

Background of the Invention

[0002] Over the years and indeed throughout human history, edge sharpening devices have taken many different forms and have been made from many different materials. In contemporary times, one of the more popular materials is alumina ceramic that has been fabricated by compaction of powdered material and fired at high temperatures to produce a hard, dense solid product. Other methods of manufacture include high-pressure compaction of ceramic slurries or powders with binder materials added. In all such cases the final product is subjected to high temperatures and, in some cases, pressures, to produce a very hard, dense shape that will sharpen or hone a cutting edge. However, ceramics so produced are somewhat brittle and susceptible to damage in the form of chipping or breakage when dropped or impacted by hard objects.

[0003] Regardless of the geometric shape of the sharpening or honing device, it is the material from which it is manufactured that is the determining factor in its effectiveness at creating and maintaining a sharp cutting edge. Ceramic is the material of choice to produce extremely sharp edges. But solid or monolithic ceramic materials, having some glass-like properties, are prone to chip or break.

[0004] Solid ceramic materials, even as relatively coarse embedded grain, are not best suited for the removal of more than minimal amounts of material from a cutting edge. Harsh abrasives like silicon carbide or super-abrasives like diamond are better suited to remove greater quantities of basis or edge support material – that is, metal or other material not proximate to the cutting edge – to, for instance, repair and regenerate a cutting edge that has been damaged by misuse or has become severely dulled. Once the cutting edge profile has been restored by use of the more abrasive materials, a ceramic device may be used to produce and maintain a fine, razor sharp edge.

[0005] There remains a need for a sharpening device having ceramic surfaces that will not chip or break. Further, it would be desirable to combine in a single sharpening device the ability of the known abrasives to remove larger amounts of material with the finer honing abilities of ceramic.

Summary of the Invention

[0006] The present invention provides a strong metallic substrate, not susceptible to chipping or breakage, the surface of which has been converted to a ceramic applied electrolytically in a particular manner. The process we prefer for creating a hard ceramic surface is described by Samsonov and Hitterer in US Patent 5,616,229. They propose the formation of ceramic coatings of up to 300 microns thick within about 90 minutes through the use of an alternating current of at least 250 volts having a shaped wave (not the conventional sinusoidal form) which rises from zero to its maximum height and falls to below 40% of its maximum height within less than a quarter of its full alternating cycle, thereby causing dielectric breakdown, the alternating current being imposed on an electrolytic bath in which the metal subject to be treated is an electrode, the bath comprising initially an alkali metal hydroxide and in a later step including an oxyacid salt of an alkali metal, such as sodium tetrasilicate. While the '229 patent speaks of forming coatings on aluminum surfaces, the authors do not treat the possible use of such a coating process for application to the unique contours of aluminum or other shapes designed for sharpening devices. The entire specification of the Samsonov and Hitterer patent 5,616, 229 is incorporated herein by reference, as we use its teachings in the creation of ceramic coatings on our sharpening devices. It should be observed that the ceramic coating is not merely laid down on the metal surface, but the surface of the metal is actually transformed by the drastic action of the current acting on it, i.e. the dielectric breakdown in the presence of the electrolytic bath ingredients. Aluminum is preferred as the substrate metal, but other

metals may be used, particularly titanium, magnesium, beryllium and alloys thereof.

[0007] We use a modified shaped-wave electrolytic process to form a hard coating on the incipient sharpening device. The process may use the teachings of US Patent 5,616,229 and accordingly that patent is hereby incorporated by reference, in its entirety, into this disclosure. However, the '229 patent uses two distinct electrolytic baths for the substrates discussed, and we have found it is not necessary to do so for sharpener stock, particularly of aluminum. The ceramic layer is formed by conversion of the aluminum or other metal surface to a hard, wear resistant ceramic by a microarc oxidation process employing an electrolyte and controlled high voltage alternating current to create a plasma discharge at the interface between the aluminum or other metal element and the electrolyte.

[0008] Our method includes forming a hard coating on the incipient sharpening device by immersing it first in an electrolytic bath comprising (deionized) water, an alkali metal salt or hydroxide (preferably potassium hydroxide) as an electrolytic agent, at a concentration of 0.5 – 7 grams per liter (preferably 0.5 – 3 grams per liter), and, as a passivating agent, a colloidal suspension of sodium silicate in the form $Na_2O \cdot xSiO_2$ (x=>2.55 by weight) at a concentration of 2-15 grams per liter while conducting through the bath a modified shaped-wave alternating electric current from a source of at least 250-800 volts through the surface of the incipient

sharpening device. The modified shaped-wave electric current rises from zero to its maximum height and falls to below 40% of its maximum height (amplitude) within less than a quarter of a full alternating cycle, thereby causing dielectric breakdown and the formation of a dense, hard ceramic film on the incipient sharpening device surface.

[0009] Thus our invention includes making a sharpening device comprising forming a hard coating on an incipient sharpening device by (i) immersing the incipient sharpening device in an electrolytic bath comprising a passivating agent and an electrolytic agent, and (ii) passing a modified shaped-wave alternating electric current from a source of 250 to 800 volts through the surface of the incipient sharpening device, wherein the modified shaped-wave electric current rises from zero to its maximum height and falls to below 40% of its maximum height within less than a quarter of a full alternating cycle thereby causing dielectric breakdown and the formation of a ceramic coating on the sharpener surface, and removing the completed sharpening device from the electrolytic bath. Preferably, the electrode will be positioned so that it is peripherally substantially equidistant from the incipient sharpener; generally this is best accomplished with a specially designed conforming electrode.

Brief Description of the Drawings

[0010] **Figures 1a** and **1b** illustrate honing devices of our invention, having a groove for sharpening points and different types of edges.

[0011] **Figures 2a** and **2b** show an elongated triangular sharpening device covered with ceramic applied in accordance with our invention; one of the sides in **Figure 2b** includes an abrasive surface.

[0012] **Figure 3** shows a set of tapered honing devices of our invention.

[0013] In **Figure 4**, the metal bar has wide radius curves, and a recess is shown without the abrasive strip.

[0014] **Figure 5** shows a bench mount sharpener utilizing sharpening wheels of our invention.

[0015] In **Figure 6a**, we show a conforming electrode of our invention, for use in assuring adequate ceramic coating on all surfaces of an elongated triangular sharpener. **Figure 6b** is an enlarged view of the holes in the conforming electrode. The disposition of the incipient sharpener is shown in the electrolytic bath in **Figure 6c**.

Detailed Description of the Invention

[0016] Referring now to **Figure 1a**, a honing device is made from solid metal, preferably aluminum. It may be cast, extruded or

fabricated from metal stock such as bar stock. The metal body **1** is covered by a ceramic layer **2** from 0.001 inch (25μ) to 0.012 inch (300μ) thick. The ceramic covering extends into V-groove **3** designed for sharpening points such as fish hooks. V-groove **3** is preferably about 60 degrees at its apex, but may vary from 30 to 75 degrees. The device of **Figure 1a** has corner edges **4** of about 90 degrees. The sharpening device is preferably designed to be hand-held or mounted in a suitable base, and therefore is generally from about 2 to about 12 inches long and ½ inch to four inches wide. Our ceramic creating process assures that the ceramic coating on edges **4**, as well as the other surfaces, will be durable and serviceable for long periods.

[0017] **Figure 1b** shows a device of our invention similar to that of **Figure 1a** except that the edges **5** are rounded and an abrasive strip **6** is shown to be affixed into recess **7**. Recess **7** and abrasive strip **6** may be of any convenient length and width. Recess **7** is part of the basic metal body, and accordingly may be covered with a ceramic layer during the electrolytic ceramic forming process described. The abrasive strip may be any hard particulate or granular grinding material adhered to a base strip, such as grits **29** of silicon carbide, aluminum oxide, or diamond. The strip we prefer is a self-adherent flexible strip having the abrasive particulate matter adhered to it. It is not necessary to include a recess **7** for the strip **6** – that is, strip **6** may be affixed directly onto a surface of the metal body, whether or not it is already covered with a ceramic layer. We prefer, however, that

the abrasive strip be cemented or otherwise adhered to a surface already covered by ceramic, as our ceramic coating provides a surface more compatible with most cements and adhesives than the bare metal. Flexible adhesive abrasive strip may be applied to gently curved surfaces as well as substantially flat ones. A V-groove **3** is similar to that of **Figure 1a**.

[0018] **Figure 2a** is an elongated triangular shaped sharpening device having 60° corner edges **8**; the device is covered with our ceramic coating **9**, and preferably also on ends **10**. In **Figure 2b**, one side of the device includes a recess **11** for an abrasive strip **12**, and the edges **13** are rounded to a small radius. A V-groove **3** may also be used. The depicted equilateral triangular shape profile is not essential – any desired or convenient combination of angles may be used for the triangular sectional shape. Other metal bar stock may be used in the electrolytic ceramic coating process – that is, a hexagonal or octagonal profile may be desired to provide both flat surfaces and edge angles wider than the triangular bar stock would normally provide. Likewise any desired shape, length, and width may be used for the abrasive strip **12**.

[0019] **Figure 3** shows a family of honing sticks and paddles for which our invention is especially advantageous. The honing sticks **13** and **14** are seen to be mounted on handles **15** and **16**. Honing stick **13** is of a substantially cylindrical shape. Generally it will be desirable to make the honing stick **13** from 2 to 14 inches long and the

diameter from 1/8 inch to 2 inches. The metal body on which the coating is fixed can be solid or tubular. Honing stick **14** is tapered. The degree of tapering will depend to some extent on the length of the honing stick; the honing stick may end in a point, but we prefer to use a blunt end **17**. The entire honing stick **14** is covered with the ceramic coating applied by the process described above. Honing stick **18** is knurled, as may be seen by the knurling pattern **19** and also has a handle **20**. The ceramic application process described above is well adapted to create a ceramic coating on the knurled surface of the underlying metal body which, again, may be tubular or solid metal, but we prefer solid metal for the knurled honing stick. Paddle **21** is of a generally flat shape and size which can be conveniently fixed to handle **22**.

[0020] **Figure 4** shows a curved surface **23** of wide radius, and a recess **11** before an abrasive strip is fixed to it.

[0021] **Figure 5** shows a bench mount sharpener utilizing sharpening wheels of our invention.

[0022] Clamp **31** secures the housing **30** to bench segment **32**. Shafts **34** pass through housing **30** and support sharpening wheels **32** and **33**. A double series of wheels **32** and **33** is preferred as shown. The wheels **32** and **33** are coated with ceramic as described elsewhere herein and the sharpener is made in an otherwise conventional manner.

[0023] In **Figures 6a, 6b**, and **6c**, we illustrate how a special electrode **40 (Figure 6a)** or **54 (Figure 6c)** is disposed around the incipient sharpener **43** or **56** in the electrolytic cell **50**. Referring first to **Figure 6a**, our conforming electrode **40** is seen to be substantially concentric with the incipient elongated triangular sharpener **43**. Encipient sharpener **43** is substantially similar to the sharpener of **Figure 2a**, having both a V-groove **3** and a recess **11** for an abrasive strip. Internal corners **44** of the conforming electrode **11** may be designed to be a distance **B** from corners **13** of the triangular profile of the sharpener **13**; **B** is preferably rounded as shown, but the internal surface of conforming electrode **40** is not a constant distance at any point within the enclosed area. Edges **13** of the sharpener will receive the greatest value of current, but it will not be as much as it would have been if distance **B** had been made shorter. Likewise, distance **A** is seen to be greater than around the remainder of the periphery of the sharpener, and accordingly the bottom surface of recess **11** will create less ceramic than the other surfaces of the sharpener, but it should be remembered that the recess **11** is intended to be covered with an abrasive strip and will not be needed for honing. The electrode **40** has holes in it to assure a free flow of electrolyte into and out of the area occupied by the sharpener. Electrode **40** is connected to the power source through connection **41**, equivalent to cable **53** in **Figure 6c**.

[0024] In **Figure 6c**, cell **50** contains an electrolytic bath of the type described. In it is suspended an incipient sharpener **56**, connected to the power circuit by cable **52**. Also suspended is a conforming electrode **54** having holes **55** similar to holes **42** in **Figure 6a**. An even coating of ceramic is assured on the sharpener **56**, because of the conforming geometry of electrode **54**. **Figure 6**b is an expanded view of a part of a conforming electrode **40**, showing holes **42**. Holes **42** need not be evenly spaced as shown, but may be spaced randomly or, in some cases, designed to assure higher flow rates of bath solution to particular areas of the sharpener.

[0025] The bath **51** in cell **50** is an electrolyte solution comprising deionized water, 2 to 60 or more grams per liter, preferably 2 to 15 grams per liter, of a passivating agent and from 0.5 to 7, preferably 0.5 – 3, grams per liter of an electrolytic agent. The passivating agent is preferably sodium tetrasilicate, as described above, but may be an alkali metal polyphosphate, chromate, molybdate, vanadate, tungstate, aluminate, or any other silicate. Any strong salt, acid, or base capable of forming an oxide with the metal substrate of the incipient sharpener, such as H_2SO_4, KOH, NaOH, NaF, Na_2SO_4, H_3PO_4 and $NaPO_3$ may be used as the electrolytic agent, but we prefer potassium hydroxide.

[0026] Definitions

Abrading: This refers to removing larger amounts of material relative to honing. Generally it involves a grit of high hardness such as

diamond, silicon carbide, or aluminum oxide; the grit may be of a size 60μ to 400μ.

Honing: This refers to removing smaller amounts of material relative to abrading. Our ceramic surface is excellent for honing – it exhibits a surface finish of R*a* 120 to R*a* 10 and removes substantially less material than abrasion, resulting in a smooth sharp edge.

Edge: As applied to our sharpeners, the convergence of two substantially flat planar surfaces at an angle less than 150°. The edge may be rounded, preferably by a radius up to 0.2 inch, or may be sharp.